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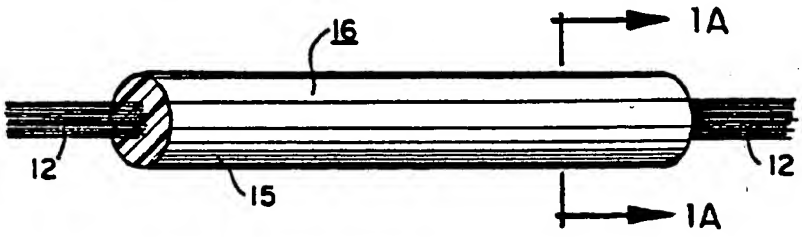
(54) Title: LOCATABLE MAGNETIC PLASTIC JACKET ON A NON-METALLIC CABLE




(57) Abstract

A locatable megnetic plastic jacket (15) on a non-metallic cable (12) locatable by a magnetic detecting device after the jacket cable (16) is buried in the ground wherein the jacket (15) is extruded from a mixture of high density polyethylene, a very low density polyethylene and finely divided particles of a permanent magnet substance such as barium ferrite.

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# LOCATABLE MAGNETIC PLASTIC JACKET ON A NON-METALLIC CABLE

## Field of the Invention

The present invention relates to the extrusion of a locatable magnetic plastic sheath or jacket on a fiber optic cable or the like and locatable by a magnetic detecting device after the jacketed cable is buried in the ground.

## Related Application

A locatable magnetic plastic duct is disclosed in our related application Serial No. 613,302 filed November 15, 1990 and entitled "Locatable Magnetic Plastic Duct and Process of Making Same". That application is incorporated herein by this reference thereto and is assigned to the same assignee.

## Background of the Invention

It is well known to extrude non-metallic flexible ducts around electrical cables or conductors or of empty duct which may incorporate a pulling cord. One particular use to which cables encased in ducts are put is in underground electrical installations. In such installations, a trench is typically dug and the duct having the cable extending therethrough is placed in the trench. Thereafter, the trench is covered with earth and the cable and duct are buried. Because the nature of the various electrical installations may vary from time to time, and further because of problems or difficulties which may be encountered with respect to various conductors of

the cable, or with the cable itself, repair or replacement of underground cables may become necessary. Electrical duct extrusion apparatus of the foregoing type is disclosed in U.S. Patent 4,508,500 incorporated by reference thereto.

It is often desirable to bury fiber optic telecommunication lines or cable in the ground. Since the fiber optic members are fragile, means of protecting the fiber optic cable from mechanical stresses are required. The two usual methods of protecting the fiber optic cable are to either include a metallic strength member on the cable itself or to place the cable inside a pipe or duct system. Duct systems made of continuous lengths of high density polyethylene (HDPE) are preferred by many telecommunication companies because an all dielectric (non-conducting) system eliminates the susceptibility of the cable to lightning damage. Apparatus for manufacturing duct of this type is disclosed in the aforesaid patent 4,508,500. The disadvantage of an all dielectric system is the lack of electrical current carrying capacity to be used with conventional methods to find the duct and cable after it is buried in the ground. When problems requiring direct access to the fiber optic cable occur, easy location of the buried cable is crucial. One method of detecting buried plastic ducts involves the use of metal such as a copper wire or strand which is run at a shallower depth over the buried duct path and which is detectable by means of well known devices such as metal detectors. Another method of locating telephone cables or electrical lines buried beneath the surface of the earth is by disposing above the lines and below the surface of the earth a flexible metal foil product, particularly a steel foil in sheet or tape form and protected against corrosion, so that the presence and general location of the metal foil is detectable from above the surface of the earth by electronic or like detecting devices. Such a method is disclosed in U.S. Patent No. 3,504,503.

It is desirable to provide a locatable plastic duct extruded from an HDPE based material which can be processed in place of the conventional HDPE material, bears a permanent magnetic field, and is non-conductive. Such plastic material should meet certain minimum mechanical strength requirements and be easily processed in the form of duct on standard extrusion equipment such as disclosed in aforesaid patent 4,508,500. Such material should be capable of maintaining a permanent magnetic field which is strong enough to be detected from the depth of approximately five feet below the ground surface. Such a duct is disclosed in our aforesaid related application Serial No. 613,302.

In some applications it is uneconomical to place the optical cable in locatable plastic duct of the aforesaid type. Also, the use of steel tape armor is considered undesirable due to the possibility of induced voltage due to electromagnetic storms which could cause the optical signal to "black out". Accordingly, it would be desirable to provide a non-conducting but locatable magnetic sheath or jacket on the optical cable which would have similar beneficial effects in tracing the previously laid non-metallic or optical cable.

**Summary of the Invention**

In accordance with the present invention there is provided a locatable magnetic plastic sheath or jacket on a fiber optic cable or the like and locatable by a magnetic detecting device after the jacketed cable is buried in the ground wherein the jacket is extruded on the cable from a mixture of high density polyethylene, very low density polyethylene and finely divided particles of a permanent magnet substance. The permanent magnet substance preferably comprises barium ferrite particles which comprises at least 20% by weight of the mixture. The mixture also preferably includes at least 20% by weight of high density poly thylen and at least 14% by weight f low density polyethylene. In one form of the invention the

very low density polyethylene and the barium ferrite particles comprise a masterbatch mixture which is 40% by weight very low density polyethylene and 60% by weight barium ferrite particles. In another aspect of the invention the mixture from which the jacket is extruded includes high density polyethylene within the range from about 20% by weight to about 66% by weight, very low density polyethylene within the range from about 14% by weight to about 32% by weight and barium ferrite particles within the range from about 20% by weight to about 48% by weight.

In accordance with a further aspect of the invention there is provided a process for manufacturing a locatable magnetic plastic jacket on a fiber optic cable or the like and locatable by a magnetic detecting device after the jacketed cable is buried in the ground comprising the steps of mixing finely divided particles of a permanent magnet substance with a non-magnetic matrix including a high density polyethylene and very low density polyethylene, heating and extruding the mixture into a jacket on the surface of the non-metallic cable, cooling the jacketed cable, and magnetizing the cooled jacket on the cable by passing the jacketed cable through an electromagnetic field.

**Brief Description of the Drawings**

Fig. 1 is a perspective view showing a locatable magnetic flexible plastic jacket on a non-metallic cable manufactured according to the present invention.

Fig. 1A is a cross section taken along the lines 1A-1A in Fig. 1.

Fig. 2 is a plan view in schematic form of a system for manufacturing the jacketed cable of Fig. 1.

**Detailed Description of the Preferred Embodiment**

In accordance with the present invention the extrusion on a fiber optic cable 12 of a jacket 15 comprising ferrite or like material incorp rated in a special medium which is added to a thermoplastic polymer

and then magnetized to produce a jacketed cable 16, Figs. 1 and 2, provides the basis for detection of a non-metallic cable which is directly buried in the ground. The incorporation of ferrite or like material in an extruded thermoplastic jacket enables the jacketed cable to be found even if buried in the ground and all evidence of precise location is not available. The locatable jacketed cable 16 manufactured according to the present invention will retain its magnetism for an indefinite period so that a considerable time may lapse between burial of the jacketed cable and the time an accurate route has to be traced. Incorporation of the ferrite containing material and magnetic alignment is performed at normal processing speed using conventional extrusion apparatus and then through suitable magnetizing equipment.

Permanent magnets of barium ferrite filled polymers have been well known for many years. For example, see U.S. Patent 3,051,988. The most common use of such magnets is in refrigerator door seals. Because heavy filler loading and high flexibility are required for most applications, polyethylene type polymers have not been used as the carrier polymer for the barium ferrite. Polyethylene homopolymers such as HDPE are not suitable carriers because they have high crystallinity and low polarity which makes it difficult or impossible to obtain heavy filler loadings.

It is common for barium ferrite filled compositions to contain upwards of 90% by weight barium ferrite; whereas, the maximum filler loading possible with HDPE is about 10% by weight which is unacceptably low for a locatable jacket application. To overcome this limitation, a new type of polyethylene namely a very low density polyethylene (VLDPE) sold by Union Carbide under the designation DFDA-1138 NT has been chosen as a carrier for the barium ferrite. Because very low density polyethylene (VLDPE) has low crystallinity, it can therefor bear up to at l ast 60% by weight barium ferrite. However, the VLDPE

is much weaker than HDPE which precludes it from use as jacket compound for direct unground burial uses. The HDPE has a specific gravity of about 0.94 to about 0.96 and VLDPE has a specific gravity of about 0.89 to about 0.915.

Being a homopolymer VLDPE is compatible with HDPE so that HDPE can be mixed with the VLDPE/barium ferrite composition to increase the mechanical strength of a final composition. A mixture of HDPE, VLDPE, and barium ferrite has been obtained which contains at least 20% by weight barium ferrite, meets minimum mechanical requirements, and can be extruded on conventional extrusion apparatus.

The apparatus disclosed in patent 4,508,500 was specifically designed to extrude duct having cable extending therethrough. As shown and described in that patent the duct 10 was illustrated with a cable comprising a plurality of individual conductors 12. As shown in Fig. 4 of that patent a means was provided which precluded contact between the conductors 12 and the just-extruded duct 10, while the walls of the duct 10 are molten or semi-molten. This means comprises a flexible metal conduit 98 which was inserted in the bore 60 of the extrusion die chamber 32 and runs the entire length of that chamber and into and through substantially the entire length of both the first and second portions 38 and 40 of the differential pressure calibrating tank 24. The conductors 12 move through the center of the conduit 98 from right to left as shown in Fig. 4. In the present invention, the flexible metal conduit 98 is eliminated so that the cone of molten resin will be applied directly to the surface of the cable formed by the conductors to form a jacket on the cable. Since the magnetic jacket is tight on the cable 12, the provisions for sizing the duct disclosed in patent 4,508,500 are not required. A schematic illustration of the extrusion apparatus disclosed in Patent 4,508,500 and modified as described above is illustrated in Fig. 2 of the present application with corresponding parts identified with reference characters corresponding to those used in

the patent. As shown in Fig. 2 the system 20 preferably includes three components namely an extruder 22, a tank 24 for cooling the just-extruded jacketed cable and a cooling trough 26 for further and final cooling of the jacketed cable after it traverses the tank 24. The extruder 22 preferably comprises a resin hopper 28 for receiving resin pellets of HDPE and compound pellets of VLDPE and BaFe. The extruder 22 preferably includes a feed screw mechanism 30 for heating and conveying the pellets and for directing extrudable material to an extrusion die chamber within the extruder 22. The extrusion die chamber preferably includes an input opening 34 to which the fiber optic cable 12 is directed to a die orifice 36 from which just-extruded magnetic jacket 15 emerges with the cable 12 encased therein to form the jacketed cable 16. After the locatable magnetic plastic jacket 15 on the non-metallic cable 12 has been cooled, the jacketed cable 16 may be magnetized by passing it between the poles of a strong electromagnet, Fig. 2, with a field strength of about 10,000 Oersteds (Oe). After the locatable magnetic jacketed cable 16 is buried in the ground, it may be located with a detection device such as a hand held wand that contains one or more magnetometers from which magnetic flux density is detected and an audio signal is emitted in proportion to the flux density. This type of detection device is well known and is commonly used to detect the magnetic fields generated by electric current in cables. A suitable composition of the plastic locatable jacket is a combination of an ASTM D-1248 Grade P34 high density polyethylene (HDPE) such as Union Carbide's HFDA-7580 NT and a masterbatch mixture which is 40% by weight of Union Carbide's DFDA-1138 NT very low density polyethylene (VLDPE) and 60% by weight Stackpole Corporation's Ceramagnet BG-1 barium ferrite (BaFe).

Various ratios of the masterbatch mixture and HDPE were mixed and examined to determine the total loading

versus final physical properties of the extruded product. The following are examples.

Example No. 1

This example had a ratio of 52/48% by weight mixture of masterbatch mixture/HDPE giving a final mixture of 20.8% by weight VLDPE, 31.2% by weight BaFe and 48% by weight HDPE.

Larger ratios of the masterbatch mixture/HDPE have been successfully extruded and tested for physical properties to vary the percentage of barium ferrite in the final mixture. It is expected that the larger ratios will enhance the capability of detection since they contain a larger percentage of barium ferrite. The capability of detection may also be enhanced by increasing the cross sectional area of the jacket.

Example No. 2

This example had a ratio of 58/42% by weight mixture of masterbatch mixture/HDPE giving a final mixture of 23.2% by weight VLDPE, 34.8% by weight BaFe and 42% by weight HDPE.

Example No. 3

This example had a ratio of 72/28% by weight mixture of masterbatch mixture/HDPE giving a final mixture of 28.8% by weight VLDPE, 43.2% by weight BaFe and 28% by weight HDPE.

Example No. 4

An example near the upper limit of loading is 80/20% by weight mixture of masterbatch mixture/HDPE giving a final mixture containing 32% by weight VLDPE, 48% by weight BaFe and 20% by weight HDPE.

Example No. 5

An example near the lower end of the loading of masterbatch mixture in HDPE is 34/66% by weight mixture of masterbatch mixture/HDPE giving a final mixture containing 13.6% by weight of VLDPE, 20.4% by weight BaFe and 66% by w ight HDPE.

From the foregoing examples it will be seen that the mixture includes high density polyethylene (HDPE) within the range from about 20% by weight to about 66% by weight, very low density polyethylene, (VLDPE) within the range from about 14% by weight to about 32% by weight and barium ferrite particles (BaFe) within the range from about 20% by weight to about 48% by weight.

While there has been described a preferred embodiment of the invention using barium ferrite particles in the magnetic jacket, it will be understood that further modifications may be made without departing from the spirit and scope of the invention as set forth in the appended claims. For example other permanent magnet materials may be used such as manganese-bismuth compounds and iron-strontium.

**What is claimed is:**

1. A locatable magnetic flexible plastic jacket on a non-metallic cable and locatable by a magnetic detecting device after the jacketed cable is buried in the ground to a depth of about 5 feet wherein said jacket is extruded tightly on the surface of the cable from a mixture of high density polyethylene, very low density polyethylene and at least 20% by weight finely divided particles of a permanent magnet substance.

2. A cable jacket according to claim 1 wherein said permanent magnet substance comprises barium ferrite particles.

3. A cable jacket according to claim 1 wherein said mixture includes at least 20% by weight of high density polyethylene and at least 14% by weight of very low density polyethylene.

4. A cable jacket according to claim 3 wherein said mixture includes high density polyethylene within the range from about 20% by weight to about 66% by weight, very low density polyethylene within the range from about 14% by weight to about 32% by weight and barium ferrite particles within the range from about 20% by weight to about 48% by weight.

5. A process for manufacturing a locatable magnetic flexible plastic jacket on a non-metallic cable locatable by a magnetic detecting device after the jacketed cable is buried in the ground comprising the steps of mixing finely divided particles of a permanent magnet substance with a non-magnetic matrix including a high density polyethylene and a very low density polyethylene, heating and extruding the mixture into a jacket on the surface of a cable, cooling the jacketed cable, and magnetizing the cooled jacket on the cable by passing the jacketed cable through an lectromagnetic field.

6. A process according to claim 5 wherein said jacket on the cable is magnetized by passing the jacketed cable between the poles of an electromagnet with a field strength of at least 5,000 oersteds.

7. A process according to claim 5 wherein said non-metallic cable comprises a plurality of fiber optic elements within a plastic sheath and said mixture is extruded into said jacket onto the surface of the plastic sheath.

8. A process according to claim 5 wherein said mixture comprises at least 20% by weight of finely divided particles of permanent magnet substance.

9. A process according to claim 8 wherein said permanent magnet substance comprises barium ferrite particles.

10. The process according to claim 9 wherein said mixture includes at least 20% by weight of high density polyethylene and at least 14% by weight of very low density polyethylene.

11. A process according to claim 9 wherein said very low density polyethylene and said barium ferrite particles comprise a masterbatch mixture which is 40% by weight very low density polyethylene and 60% by weight barium ferrite particles.

12. A process according to claim 11 wherein said mixture includes high density polyethylene within the range from about 20% by weight to about 66% by weight, very low density polyethylene within the range from about 14% by weight to about 32% by weight and barium ferrite particles within the range from about 20% by weight to about 48% by weight.

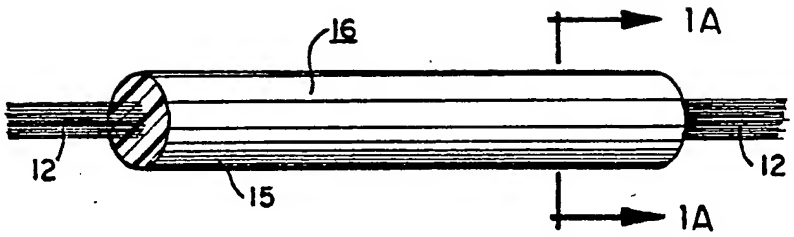


FIG. 1

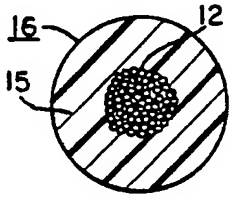


FIG. 1A

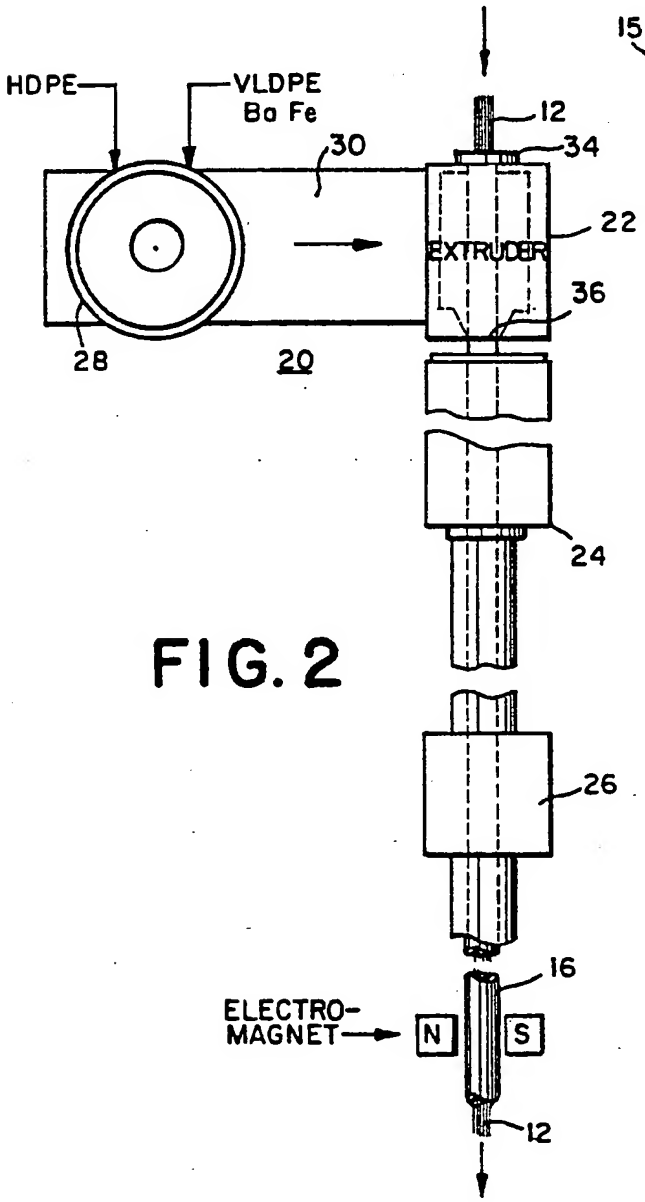


FIG. 2

# INTERNATIONAL SEARCH REP RT

International Application No. PCT/US91/09721

## I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5):F16L 57/00; H01B 7/28; B29C 47/00
U.S. CL.:405/157; 264/22

## II. FIELDS SEARCHED

Minimum Documentation Searched [7]

| Classification System | Classification Symbols |
|---|---|
| U.S. | 405/154,157<br>116/209; 138/104,105, 174/37<br>264/22, 104, 108 |

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

## III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

| Category * | Citation of Document, [11] with indication, where appropriate, of the relevant passages [12] | Relevant to Claim No. [13] |
|---|---|---|
| Y | US,A, 4,508,500 (FRENCH) 02 APRIL 1985<br>(see fig. 3, col. 5, lines 23-45) | 1-12 |
| Y,P | US,A, 5,036,210 (GOODMAN) 30 JULY 1991<br>(See figures 1-5, col. 4, line 30-col. 5, line 50) | 1-12 |
| A | US,A, 3,051,988 (BAERMANN) 04 SEPTEMBER 1962<br>(See the entire document) | 5-12 |
| A | US,A, 3,121,131 (BLUME) 11 FEBRUARY 1964<br>(See the entire document) | 5-12 |
| A,P | US,A, 5,006,402 (ISAYEV) 09 APRIL 1991<br>(See the entire document) | 1-5 |
| A | DE,A, 28 32 547 (WIRSBO PEX GMBH 07 FEBRUARY 1980<br>(See the entire document) | 1-5 |

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## IV. CERTIFICATION

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| 14 APRIL 1992 | 08 MAY 1992 |
| **International Searching Authority** | **Signature of Authorized Officer** |
| ISA/US | DAVID H. CORBIN |

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